P/REFERENCES OF DESIGN

DESIGN FOR THE ENHANCEMENT OF THE AGRIFOOD SUPPLY CHAIN. TOWARDS THE TRANSFORMATION OF CEREAL WASTE INTO A COMPETITIVE INDUSTRIAL PRODUCT.

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ABSTRACT | Investigating the food system towards goals of stability and sustainability, the research aims to explore – through the specificities of the systemic design approach, able to jointly consider multiple and different information, actors, and strategies – the possibilities and development potential of agro-food waste regeneration processes in a logic of co-evolution (Fassio & Tecco, 2022) oriented towards the development of industrial constructive and restorative solutions, able to influence the environmental, economic and social dimension (Antonelli & Tannir, 2019) of the supply chain on which it works.

Intending to increase the enhancement of the agri-food chain and reduce environmental impacts, the research proposes a qualitative investigation in the field of the transformation of industrial cereal waste into competitive industrial products within which the different design approaches – related to experiments with the matter, Material Design; to technologies and methods for the design of products, Product Design; and to the optimisation and transformation of production processes, Process Design – can synergistically and strategically collaborate through the use of the systemic design approach.

Through systematising the literature and analysing case studies, the research investigates the characteristics of agro-food waste, the reuse processes, and the companies/start-ups that process them. A series of representative and interpretative diagrams will clarify tools, methods, and practices, enriching the research contribution. The emerging solicitations will induce a phase of direct and indirect experimentation with specific research centers and production contexts whose socio-environmental impact on the territory will be assessed.

The final goal of the research is to enhance agro-food waste into a competitive industrial product realised through hybrid innovation practices. Among these, industrial symbiosis processes between companies in the same agrifood chain are critical.

The theorization and prefiguration of industrial symbiosis between different production supply chains represent a further departure from originality.

The possible merger between the identified cereal supply chain and other Italian production chains with a high environmental impact is proposed both as one of the challenging goals of the research and as a prospect of originality.

1. Foreword: Food System and Ecological Transition

Taking as the premise of the research the complexity of the food system – evident in issues such as the fragmentation of relations between supply chains, partially interconnected with each other, the extension of the scope of action able to act on a local and/or global scale (Pauli, 2017) – embedded in a condition made critical by the effects of climate change and the uncontrolled exploitation of environmental resources (Peppoloni & Di Capua, 2022), the research investigated the socio-cultural context and design practices to contribute to the enhancement of the agri-food supply chain through the reuse of its waste.

Food, indeed, as a mediator of human relations able to involve the individual, the community, and governance, takes on in this context the features of strategic, transdisciplinary, and multifocal projecting areas (Descola, 2005), explorable at many levels, from the socio-political to the economic to the environmental.
In each of these, waste plays a role as a characterising part of the production, transformation, and consumption processes.

Various International Institutions have discussed the peculiarities, potential, and extension of projects related to food and, more generally, the agro-food supply chain.
European Commission (EU) with the Farm to Fork strategy (European Commission, 2020; European Commission, 2021) contained within the broader Green Deal; United Nations (UN) with the 17 Sustainable Development Goals SDGs (Agenda 2030, 2021; European Commission, 2017) of the 2030 Agenda; and Food and Agriculture Organisation (FAO) with the Urban Food Agenda (Marino et al, 2020 p.10; FAO, 2019) have promoted projects and programmes that have also highlighted the potential generated by the reuse of agro-food waste (European Commission, 2017).

The Italian Department for Cohesion Policies, with suggestions, guidelines, and regulations on the Bioeconomy, has also converged along these lines.
Some of the proposed strategies suggested strengthening the sustainable production of waste and its conversion into industrial products through integration between sectors, systems, actors, and institutions (Agenzia per la Coesione Territoriale, 2016) by promoting industrial symbiosis interventions (European Commission, 2022), therefore promoting the merging of two or more industrial sectors.
Industrial symbiosis has been a resource-use optimization strategy involving industries to generate competitive benefits for companies through different approaches, including transferring resources, such as matter, energy, space, technology, skills, etc. (Renner, 1947; Chertow, 2007).

From the point of view of design, the approach that most relates to industrial symbiosis is systemic design. In this context, the area investigated is that of micro-small companies (MPI), which, in addition to being a constitutive element of the Italian production system, are also characterised by flexibility and adaptation to changes and innovations (Barbero, 2016).

The systemic approach, condensed in Table 1 (below), makes it possible to interpret the relationship between territory and community by enabling the development of design actions that favour the triggering of sustainable enhancement processes of local resources (Gaiardo et al., 2022) or to act as a mediator by stimulating the meeting between different knowledge and expertise to promote contamination, participation, and collaboration between them; or to use data as raw material to create new forms of value that push design to understand the context and take on the role of activator of experiences (RIBA and ARUP, 2013).

Table 1. Interpretative diagram of design action through the systemic approach.

DESIGN ROLE	ACTION	GOALS
Interpreter	Projects between Territory and Community	It **Triggers** Processes of Enhancing Local Resource
Mediator	Encounter between Knowledge	It **Promotes** Contamination, Participation and Collaboration
Enabler	Data as Raw Material	It **Understands** the Framework and Proposes Experience

Design actions within the agrifood supply chain interpret and adapt the specificities of the systemic approach to the context, the company, and the reference actors.
In this context, systemic action promotes interventions able to take into account the causal relationships between the actors and the feedback flows between the elements of the supply chain, operating syntheses of the interactions emerged from the mapping of systems (Acaroglu, 2017), which offer possibilities for design actions (Figure 1).

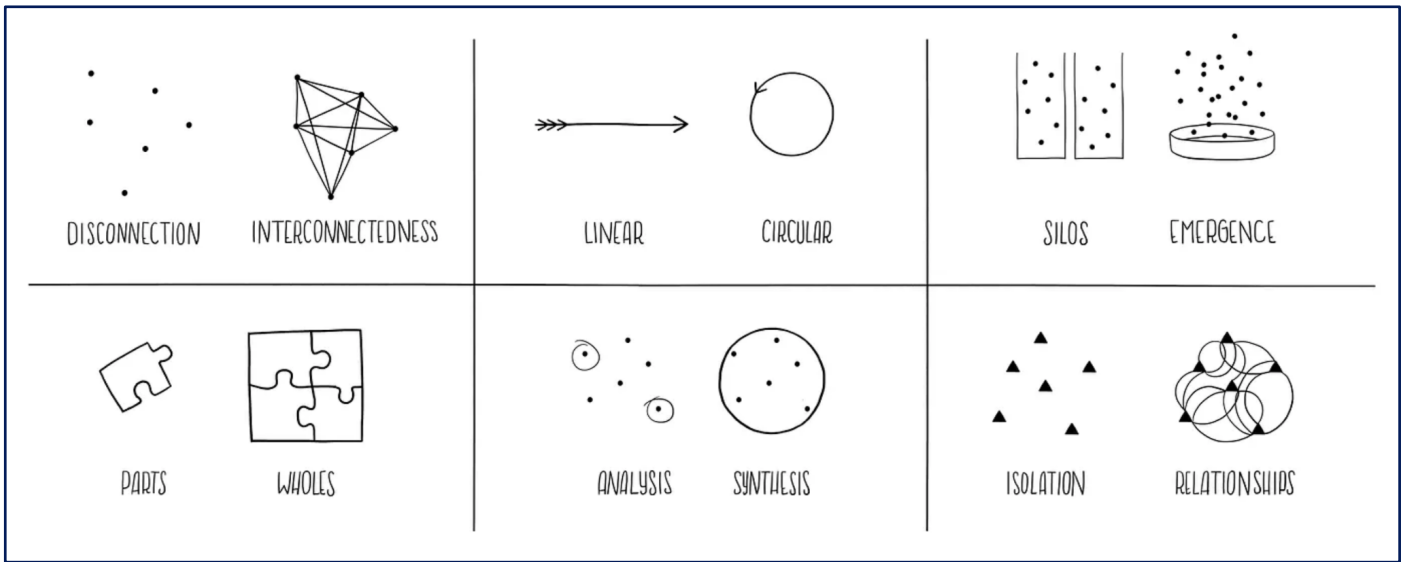

Figure 1. Interpretative diagram of design action through the systems approach. Credits: Segal, E. (Illustrator). (2017, 7 September). Tools of a system thinker [digital image]. Extract from https://medium.com/disruptive-design/tools-for-systems-thinkers-the-6-fundamental-concepts-of-systems-thinking-379cdac3dc6a .

Within the industrial sphere, a field investigated explicitly by the research, these characteristics can be declined on the analysis of industrial processes aimed at their optimisation (Jones, 2014), on the verification of input-output processes to limit waste and reduce environmental impacts (Bistagnino, 2012; Meadows, 2008), or on the reuse of production waste to operate in open and collaborative systems (Capra and Luisi, 2014).

The research proposes scenarios for the enhancement of the agrifood supply chain identified through the study of the transformation of the industrial waste it produces, the analysis of the potential and development limits of waste enhancement processes, the testing of stakeholders and their synergies, and

the identification of supply chains to be enhanced in a logic of environmental and economic co-evolution. Research also includes the reuse of waste within Life Cycle Assessments (LCA) to reduce the environmental impact of the supply chain (Vinci, 2022) and, in parallel, promote open supply chain strategies (Bertalanffy, 1968).

2. Field and Goals: Waste as a Resource

The triggering of transformative waste processes creates the conditions for configuring competitive and bio-based industrial products to enhance the agro-food chain.
In pursuing this goal, the research uses a systemic analysis of agro-food waste, critically ordered through parameters, categories, and qualitative and quantitative characteristics, to identify the supply chain to work on.
The analysis of the present condition makes it possible to identify the cereal chain as the one on which to work at an experimental level thanks to the physical characteristics of the waste due to the reduced environmental impact of the transformation processes and the possibilities of maximizing enhancement actions, overcoming what usually happens.
To date, cereal waste, the result of industrial processes, if disposed of, increases environmental pollution and generates only a minimal contribution to the supply chain if transformed into animal feed.

By implementing processes for the regeneration of industrial cereal waste into industrial products through adopting traditional and local transformation processes, the experimental phase proposes the prefiguration of scenarios to enhance the supply chain.
Operating at a local level, with low environmental impact transformation strategies and waste regeneration projects, it acts within open supply chains to generate a high economic impact and increase the value of the companies involved, the supply chain, and the territory.

3. Methodology: The Systemic Approach to Waste Enhancement

Taking as its basis the necessity to adopt a trans-disciplinary and interdisciplinary approach to the contemporary context, the research moves by examining socioeconomic, governance, and environmental conditions, investigating scientific studies and territorial inclusive policies, and exploring, through the methodology of systemic design, areas of action and design practices.

In the first phase of the explorative research, in which the activities of literature review and selection of case studies, sometimes consequential and sometimes parallel, allow us to understand the state of the art and define the field of investigation, a second interpretative phase is inserted through which we proceed to the critical reading of the case studies and to the individuation of the supply chain on which to carry out the subsequent experimental phase, still partially being defined.

3.1 Explorative and Interpretative Phase: From Literature Review to Database Construction

The literature review was based on investigating four research fields: social sciences, international politics, industrial symbiosis processes, and systemic design. The literature review made it possible to identify concepts, trends, and strategies for each and relate them as part of a system (Figure 2).

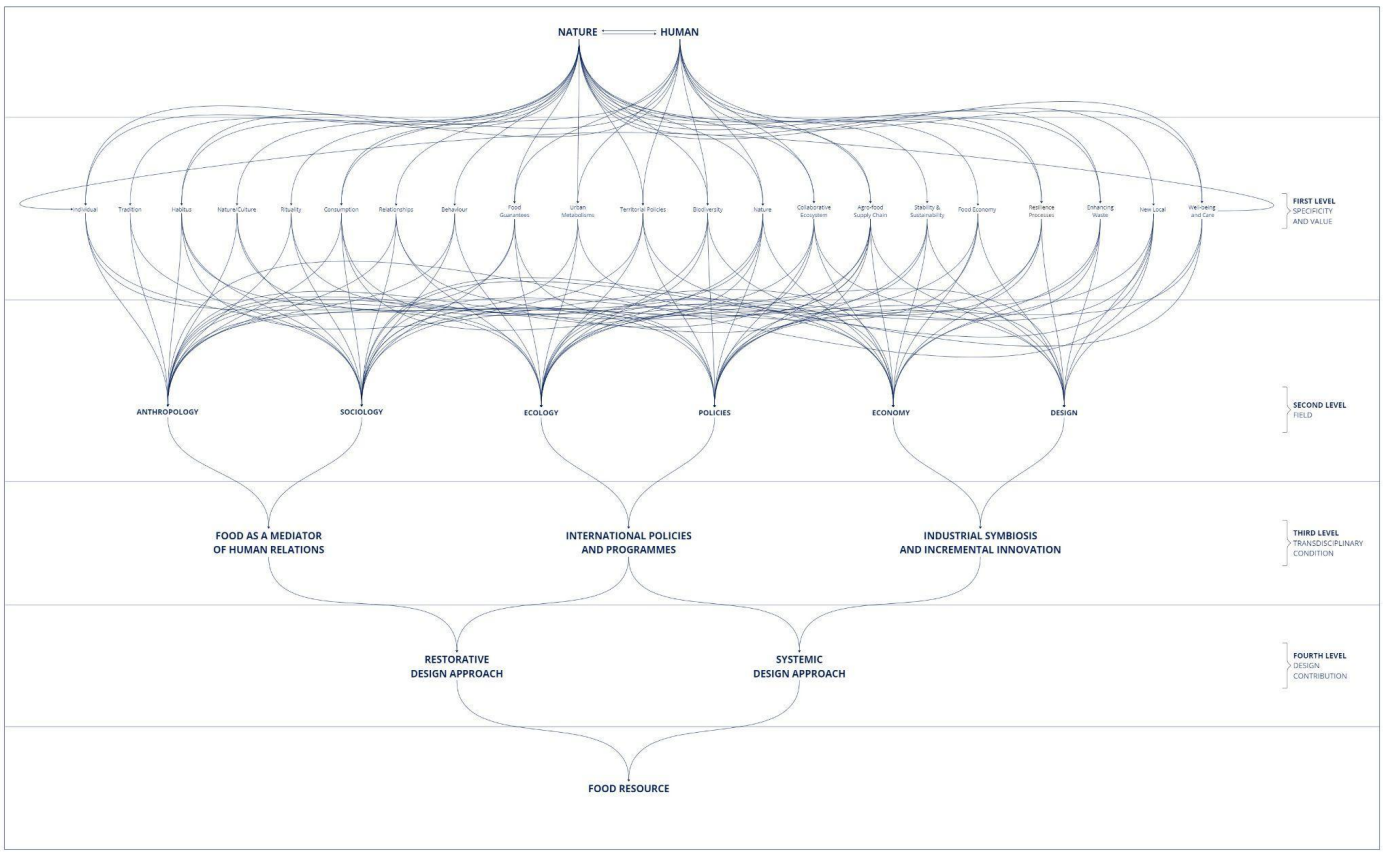

Figure 2. Interpretative diagram showing the existing correlations within the reference literature. Credits: Francesca Ambrogio.

The setting up of a qualitative database defined and systematised the research framework within the real context.
An early survey collected 128 case studies found through desk research that could be clustered into surplus recovery processes, participative guarantee forms, and waste reuse processes.
The focus on waste reuse processes reduced the selection to 43. The cases were then cross-referenced with the reference literature and with what emerged during the previous analyses.
For each case, the qualitative characteristics of waste, its processability, the possible transformation processes, and the interlocutors were then noted.

The selection of the case studies was finalized by organising a database (LINK[1]) composed of four parts, defined according to specific parameters that emerged from the literature review and case study research.

Given the goal of the research, aimed at the enhancement of the agro-food supply chain, the creation of the database served to draw up a mapping of the waste transformation processes on the Italian territory to understand the approaches that generated the origin of these processes and how they work; and to identify the actors of possible technology transfer that can be activated within the agro-food supply chain or between different supply chains.

A critical interpretation of the database made it possible to identify the sustainability level of waste transformation processes and final products to understand what forms of relations and what network formalizations exist among supply chains and actors, to understand how waste transformation methods are influenced by their qualitative characteristics; to map out the general motivations that push towards the definition of agro-food waste reuse processes, the specific motivations that concern the reuse of waste within the supply chain that generated the waste as well as those that concern transformation processes aimed at other supply chains.

3.2 Experimental Phase: Towards Reuse Scenarios

Once the supply chain to carry out the experimentation has been identified, the research includes an interview, verification, and field test phase. Interviews will be conducted in selected companies to verify their production processes and the consequent waste generation.
These will be succeeded by interviews in research laboratories aimed at understanding the properties of the waste and the reusable processes that can be adopted.

Subsequently, a dialogue will be established with product designers to identify design possibilities and solutions based on the chemical, physical, and aesthetic characteristics of the material.

Further in-company discussion and verification with experts in the specific field will support and promote the effective prefiguration of reuse design scenarios. The verification phase of the results will bring to the definition of the industrial process for the reuse of waste, the environmental and economic impact of which can be measured, and the open supply chain LCA verified.

4. Conclusion

The approach promoted by systemic design applied to the verification of industrial input-output processes of the agro-food chain to contain waste and reduce environmental impacts encourages the development of an overall supply chain enhancement strategy.

The enhancement of waste derived from agro-food industrial production transformed into input for another production process can also be compared with other production supply chains by promoting new relations between actors towards developing products with a low environmental impact.

4.1. Deliverables and Impact of the Research

The research gives the scientific and professional community the reconstruction of the theoretical framework related to the identified topic, integrated through the construction of representative and interpretative diagrams.

In the explorative and interpretative phases, the research produces a database focused on agro-food waste, which can be interrogated and implemented as a source and tool for further research and projects.

The database supports the work of design researchers, who can find aggregated qualitative information on materials, production processes, and products. It broadens the choice of materials usually used by designers, who, by interrogating the database, can identify bio-based alternatives to materials of extractive origin.

In the experimental phase, it prefigures scenarios of socio-economic enhancement of the food supply chain in a process shared between researchers and companies.
Through the study and in-depth study of waste processing and transformation processes, the company virtuously uses waste for the industrial production of products with a low environmental impact.

Notes

1. The database, being a tool and a source for research, is currently only in visualisation and in Italian. The use of the Italian language was oriented by the wish to also use this database to interact with local actors and local situations with whom it would not have been possible to use an English language tool.

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Francesca Ambrogio has been a Designer PhD student in Design Studies since October 2022. She explores the multiple relationships between design and environment. The doctoral research investigates, with a systemic-regenerative approach, the enhancement of agri-food chains through the transformation of industrial waste**.**

P/REFERENCES OF DESIGN

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